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ATRAZINE PROMOTES PONDEROSA PINE REGENERATION

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ABSTRACT

Atrazine applied by helicopter improved survival of planted ponderosa pines (*Pinus ponderosa* Laws.) subjected to competition from herbaceous vegetation and to predation by pocket gophers. Atrazine also improved the seedling-establishment environment; seed fall from scattered overstory trees produced 45-percent stocking and more than 300 trees per acre (741/ha) 7 years after the herbicide was applied.

KEYWORDS: Herbicides (-natural regeneration, herbicides (-artificial regeneration, rodent control (forest), atrazine, gophers (pocket), ponderosa pine, *Pinus ponderosa*.

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Pocket gophers (*Thomomys* spp.) hinder regeneration of logged and burned lands on many western forests[2/] (Crouch 1969, Barnes 1973).

Gophers feed on stems, roots, and, to a lesser extent, foliage of seedlings and saplings of most conifer species; their feeding usually results in mortality of the trees (Crouch 1971). These animals can destroy new plantations within a year of planting or may kill a portion of the trees annually for 10 years or more. In either case, stocking is reduced. When a portion of the trees are killed, many years of potential growth are lost and costly site preparation is often needed before replanting. Moreover, replanting may not be successful unless gopher damage is controlled.

For many years, damage by gophers has been controlled by poisoning the animals to reduce their numbers (Scheffer 1910, Crouch 1933, Barnes et al. 1970). Poisoning by hand or machine has reduced damage to many agricultural crops, but there is little documentation of successful protection of tree seedlings despite treatment of tens of thousands of acres with toxic baits. Trapping has also been used to reduce numbers of gophers, but most foresters believe it is logistically unsuitable and prohibitively expensive. In either case, problems inherent with effective treatment of vast acreages of wild land, year after year in some areas, are overwhelming.

[2/] Northwest Forest Pocket Gopher Committee. 1976. Survey of pocket gopher damage to conifers in the Pacific Northwest 1975. (Mimeogr.) Oregon-Washington Silvicultural Council, Western Forestry and Conservation Association.

Clearly, a more effective technique is needed, one that is longer lasting and easier to apply.

In the 1950's Keith and others (1959) sprayed gopher-infested Colorado rangelands with 2,4-D and virtually eliminated forbs from a forb-grass vegetation complex. The next year numbers of gophers declined dramatically, apparently in response to the loss of their primary food supply. Declines in numbers of gophers after herbicide application were also noted by Howard and Childs (1959) and Hull (1971). Recently, Stewart and Beebe (1974) and Christensen and others (1974) reported improved survival of pine seedlings after treatment with atrazine.

In 1964, personnel of the Chiloquin Ranger District, Winema National Forest, treated small test plots of planted ponderosa pines (*Pinus ponderosa*)[3/] with several herbicides to reduce vegetative competition and gopher predation. The test area was located on the Cave Mountain Burn, near Chiloquin, Oregon, an area swept by wildfire in 1959, salvage-logged, and machine-planted with pines in the early 1960's. By 1964, because of gophers and other factors, the plantation was declared a failure (Barnes 1973).

Some of the tested herbicides killed trees; others, including atrazine, showed promise for promoting survival and growth. The study reported here, an expansion of the 1964 trial, was based on that work and on preliminary findings from a more complex study

[3/] Plant names follow Hitchcock and Cronquist (1973).

begun by the senior author in 1966 on a nearby site.

STUDY AREA AND METHODS

The investigation was conducted as a U.S. Forest Service administrative study, following established guidelines, and was designed to test the efficacy of atrazine combined with seeding and planting to establish ponderosa pine. In addition, bitterbrush (*Purshia tridentata*) was seeded or planted with the pine in two treatments, because shrub-dominated communities in the area appeared to support few gophers, and trees growing there incurred little damage from those rodents.

The study area was 100 acres (40.5 ha) on pumice soil, in a relatively uniform ponderosa pine-bitterbrush-needlegrass (*Stipa occidentalis*) plant community (Volland 1976). By 1967 when the study was begun, the site was occupied by widely spaced, mature ponderosa pines, scattered remnants of earlier pine plantings, and a few natural seedlings. Occasional bitterbrush and currant shrubs (*Ribes cereum*) were present, but needlegrass was the predominant cover. Forbs were rare. Gopher mounds were abundant over the entire area, and the lack of pine regeneration was largely attributed to gophers.

The entire 100-acre (40.5-ha) area was sprayed by helicopter with atrazine at 4 pounds of active ingredient per acre (4.48 kg/ha) in November 1967. Twelve 1-acre (0.41-ha) treatment plots, separated by 150-foot (45.7-m) buffer strips, were then established in blocks of four plots each within the central, most uniform part of the sprayed area. The following treatments were applied randomly at one each per block:

T_1 - Seeded with bitterbrush at 3 pounds per acre (3.36 kg/ha) with a rangeland drill in November 1968; planted with 2-0 ponderosa pine at 680 per acre (1,680/ha) in April 1971.

T_2 - Planted with 2-0 bitterbrush at 2,000 per acre (4,942/ha) in June 1970; planted with 2-0 ponderosa pine at 680 per acre (1,680/ha) in May 1970 and replanted in April 1971.

T_3 - Seeded with endrin-treated ponderosa pine seed at 6 pounds per acre (6.72 kg/ha) in November 1968.

T_4 - One-half of each plot planted with 2-0 ponderosa pine at 680 per acre (1,680/ha) in May 1970, and the second half planted in April 1971.

Unfortunately, the original plan allowed comparisons only among seeding and planting treatments. No evaluation of atrazine effect was possible, nor could atrazine plus treatments be compared with plantings where no atrazine was applied. To provide more information, local foresters added two 1-acre treatment plots on an adjacent unsprayed site. These additions were planted with 2-0 pines in spring 1970 and 1971 at the time of the final applications of the four treatments.

The original plan called for a rudimentary evaluation of seeding and planting success each year for 5 years. Results from this evaluation, on file at the Chiloquin

Ranger Station, Chiloquin, Oregon, were inconclusive.

Findings reported here are derived from data collected in 1972 and 1975 from (1) the original treatment plots and one buffer strip randomly selected from each block (ATR), (2) the added plantings on plots not receiving atrazine, and (3) unsprayed-unplanted plots we selected as representing pre-treatment environments and stocking levels comparable to those in (1) and (2).

Effects of treatment on tree establishment were evaluated by counting trees in twenty 1/250-acre (1/618-ha) circular subplots in each treatment plot. Four lines of five subplots each, spaced 25 feet (7.6 m) apart were randomly distributed in each plot for sampling. Bitterbrush plants were also counted in the subplots.

DATA ANALYSIS

Data from atrazine treatments were subjected to analyses of variance with arc-sin transformations of percentage values. Then, orthogonal comparisons were made at $P = 0.05$ to further identify similarities and differences among treatments and groups of treatments.

Findings from planted plots not receiving atrazine and from untreated and unplanted plots could not be directly compared with herbicide seeded and planted combinations because they were not included in the original block design; however, these comparisons are vitally important to managers. Therefore, mean values of tree stocking and densities were determined for the added treatments, and confidence limits were calculated to provide a measure of comparability.

RESULTS AND DISCUSSION

Observations in the 1968 growing season indicated that atrazine applied the previous fall had greatly reduced herbaceous cover. Because the scattered pine overstory prevented complete aerial coverage of the study area, the unaffected acres were ground-sprayed in November 1968.

Mature trees on the site had an exceptionally large seed crop in 1968, and cursory examinations in spring and summer of 1969 revealed many germinating seeds and seedlings in all treatment plots.

We did not visit the area again until 1972. At that time, atrazine effects were still amply evident and pine seedlings were abundant over much of the sprayed area, even where there had been no other treatment.

Results of tree counts in 1972 and 1975 are shown in table 1. Analyses indicate that planted plots had significantly better stocking and more seedlings than those not planted. Moreover, plots planted twice (T_2) had significantly better stocking and more seedlings than those planted once (T_1) or planted half one year and half the next (T_4). Seeding (T_3) produced no more seedlings than were found in plots treated only with atrazine (ATR). Although stocking and seedling densities were lower in 1975 than 1972, the relative rankings among treatments did not change.

Table 1--*Mean stocking and density of ponderosa pines on the Cave Mountain Burn study area in Oregon*

Inspection date	Treatment[1/]				
	T_1	T_2	T_3	T_4	ATR
	STOCKING PERCENT				
1972	77	100	63	90	53
1975	67	96	42	84	45
	TREES PER ACRE[2/]				
1972	1,220	1,720	685	1,025	510
1975	940	1,375	320	955	310

[1/] T_1 = seeded with 3 lb bitterbrush per acre in November 1968; planted with 680 2-0 ponderosa pine per acre in April 1971. T_2 = planted with 2,000 2-0 bitterbrush per acre in June 1970; planted with 680 2-0 ponderosa pine per acre in May 1970 and replanted in April 1971. T_3 = seeded with 6 lb endrin-treated ponderosa pine seed per acre in November 1968. T_4 = one half of each plot planted with 680 2-0 ponderosa pine per acre in May 1970 and the second half planted in April 1971. ATR = treated only with atrazine.

[2/] Trees per acre times 2.471 equal trees per hectare.

Plots seeded or planted with bitterbrush (T_1 and T_2) averaged significantly greater stocking and numbers of shrubs than other treatments (table 2). Numbers of bitterbrush plants established were however, fewer than expected when the amount of seed drilled and numbers of seedlings planted are considered. By 1975, bitterbrush cover was too sparse to influence gophers or otherwise affect the pines.

Comparisons of unsprayed-unplanted, unsprayed-planted and sprayed-planted (T_2) plots are shown in table 3. It is clear that planted plots sprayed with atrazine had far greater stocking and many more seedlings. In fact, planting without atrazine appeared little better than no treatment by 1975.

Certainly, atrazine contributed greatly to the high numbers of seedlings found in sprayed plots, but it was not possible to determine if benefits resulted from reduction of plant competition, reduction of losses caused by gophers, or both. In 1975, about 7 percent of the seedlings present on all plots had been recently killed by gophers. Although unlikely, should this rate of loss persist without additional recruitment of trees, few will survive to produce harvestable products, especially on poorly stocked plots.

Table 2--*Mean stocking and density of bitterbrush on the Cave Mountain Burn study area in Oregon*

Inspection date	Treatment[1/]				
	T_1	T_2	T_3	T_4	ATR
	STOCKING PERCENT				
1972	53	63	11	7	2
1975	42	58	9	2	4
	SHRUBS PER ACRE[2/]				
1972	240	275	30	10	10
1975	140	200	20	5	10

[1/] T_1 = seeded with 3 lb bitterbrush per acre in November 1968; planted with 680 2-0 ponderosa pine per acre in April 1971. T_2 = planted with 2,000 2-0 bitterbrush per acre in June 1970; planted with 680 2-0 ponderosa pine per acre in May 1970 and replanted in April 1971. T_3 = seeded with 6 lb endrin-treated ponderosa pine seed per acre in November 1968. T_4 = one-half of each plot planted with 680 2-0 ponderosa pine per acre in May 1970 and the second half planted in April 1971. ATR = treated only with atrazine.

[2/] Trees per acre times 2.471 equal trees per hectare.

Table 3--*Mean stocking and density of ponderosa pines growing on unplanted and planted unsprayed plots and on planted plots sprayed with atrazine on the Cave Mountain Burn study area in Oregon*

Inspection date	Treatment		
	No atrazine, unplanted plots	No atrazine, planted plots	Atrazine, planted (T_2)[1/] plots
	STOCKING PERCENT		
1972	15 ± 12[2/]	55 ± 19	100 ± 0
1975	15 ± 12	37 ± 22	96 ± 8
	TREES PER ACRE[3/]		
1972	45 ± 35	280 ± 120	1,720 ± 560
1975	40 ± 30	120 ± 55	1,375 ± 380

[1/] T_2 = planted with 2,000 2-0 bitterbrush per acre in June 1970; planted with 680 2-0 ponderosa pine per acre in May 1970 and replanted in April 1971.

[2/] Confidence intervals equal $\bar{x} \pm t.05\ (S\bar{x})$.

[3/] Trees per acre times 2.471 equal trees per hectare.

Finally, 45-percent stocking and more than 300 trees per acre (741/ha) on plots treated only with atrazine suggest that herbicide treatment might be used to enhance success of natural regeneration in years of good seed crops in stands with cone-bearing trees but highly competitive understory vegetation.

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